ELECTRONIC FUNDAMENTALS

EXPERIMENT LESSON 2

HOW TO DO ADVANCED SOLDERING

RCA INSTITUTES, INC.
A SERVICE OF RADIO CORPORATION OF AMERICA
HOME STUDY SCHOOL
350 West 4th Street, New York 14, N. Y.

Experiment Lesson 2

OBJECT

To apply your knowledge of soldering by:

1. Making several connections between tie terminals and a tube socket.
2. Soldering shielded cable and coaxial cable.
3. Making test leads, shielded leads, and clip leads.

INTRODUCTION

In building and servicing a radio receiver, there are two basic kinds of connections made: permanent connections and temporary connections.

A *permanent connection* is one that is made to last for a long time. Most permanent connections made in radio receivers are soldered. For example, a resistor soldered in place in a radio receiver is permanently connected. Each part that is soldered in place is permanently connected until it breaks down and is replaced with a new part.

However, there are times when permanent connections are not soldered. For example, radio tubes are not usually soldered in place. Instead, a special connecting device is used. This device, called a tube socket, is a permanent part of the receiver. Although circuit connections to the socket are soldered, the connections between the electron tube and the socket, while they are very tight mechanically, are not soldered. This makes it easy to disconnect tubes from the receiver for test and replacement.

There are many kinds and sizes of tube sockets used in radio receivers. No one radio uses all types, but later on you should become familiar with most of them. Fig. 2-1 shows several types.

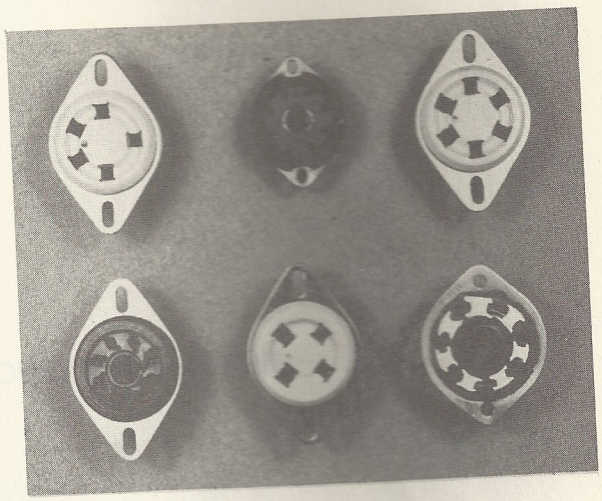


Fig. 2-1

There are other unsoldered permanent connectors used in radio receivers; for example, the attachment plug at the end of the receiver's line cord, which goes into an electric outlet and connects the receiver to the power line. In a console radio, the speaker may connect to the receiver by means of a special plug and socket. In a phono-radio combination, the phonograph may be connected to a radio chassis by means of a cord and a phono jack or plug. Figure 2-2 shows some of these connectors.

Most *temporary connections* used in testing a receiver are made to last for no more than a few hours at the most. Usually, a temporary connection is made in locating trouble when something has gone wrong with the radio; for example, connections made between a multimeter and receiver circuits, which usually last no more than a few

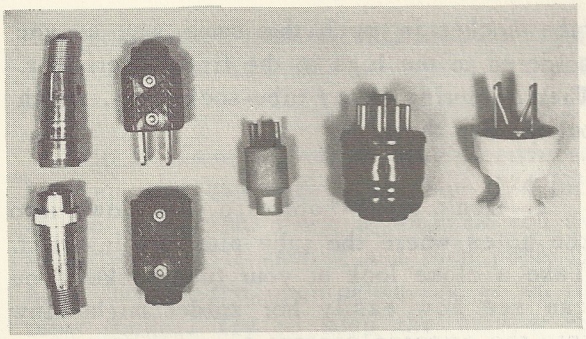


Fig. 2-2

seconds, and connections from a test oscillator or signal generator to a receiver, which may last for a few minutes or for an hour or more.

Connectors used in making temporary connections must meet certain requirements:

1. They should protect the user (the technician) from an accidental shock, burn, or other injury.

2. The connector, and the wire or cable connected to it, should not change the wave shapes or reduce the values of the electrical currents flowing through them while tests are being made.

3. The connection between each temporary connector and its wire or cable should be either soldered or mechanically tight.

4. The connector and the wire or cable connected to it should be insulated to prevent accidental shorting of electrical and radio circuits during tests.

The test leads and connectors that you will make in this lesson will meet these requirements only if you follow carefully all the directions in each job assignment.

METHOD

In the first part of this lesson, you will solder permanent connections between the lugs of two tie terminals and the lugs of a miniature 7-prong tube socket. It is easier to make connections to a large socket than to the small socket you will use; if you find that you can make good soldered connections to this miniature socket, you may be sure that you can do equally good work on any of the larger types. You will work with two kinds of shielded cable and learn two different ways of making soldered connections with them. In addition, you will assemble the following: test leads for use with the multimeter that you will start to assemble in the next lesson, a shielded test lead for use with the signal generator you will make later in the course, and a clip-to-clip lead for use in later lessons.

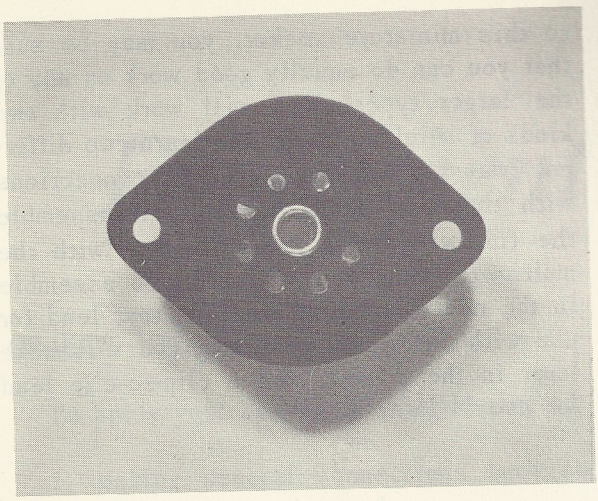
JOB 2-1

To make some soldered connections between a 7-pin miniature tube socket and some tie terminals.

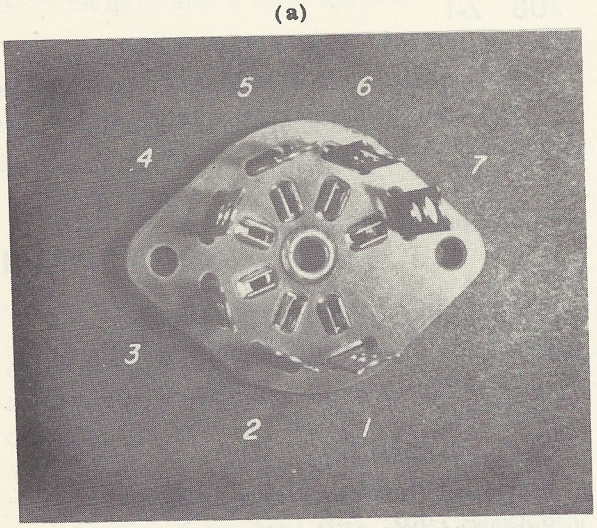
Equipment Needed.

One 7-pin miniature socket
Two wood screws (to hold socket in place)
One lug
Solid pushback wire
Spaghetti (insulated sleeving)
Soldering iron
Clean rag
Rosin-core solder
Piece of wood about 4″ x 9″

Information. Look at the small tube socket you received in Kit 1. It is called a 7-pin miniature socket because it has seven connections and is used to connect a miniature-based tube to the proper circuits in a radio. Fig. 2-3*a* shows one view of this socket. Hold the socket upside down and you will get the view of the socket shown in Fig. 2-3*b*. Now you can see seven lugs. If you examine them closely, you can see that each lug has one or two small openings into which wires may be connected and soldered. The other end of each lug forms a gripping contact in the socket base. Each of these contacts grips one of the pins on the base of the tube that is inserted in the socket. At each end of the socket is a hole that is used,



(a)



(b)

Fig. 2-3

with a rivet or a small screw and nut, to mount the socket on a receiver chassis. Notice, in Fig. 2-3*b*, that each lug is numbered. Tube manuals and radio schematics number the base pins of electron tubes and the contacts of tube sockets in a clockwise direction *when the tube or socket is viewed from the bottom*. You will notice that there is a wide space between two of the socket lugs; the socket contacts are numbered in a clockwise direction, *starting at this space*. Lug *#1* is always next to this space. Other types of electron-tube sockets are numbered in a similar way. As each type is discussed in this course, you will be shown how it is numbered.

Wire leads, resistors, and other small parts may be soldered to the lugs of your tube socket in much the same way as you soldered to the lugs in the first experiment. When soldering to any tube-socket lug, watch out for two things:

1. Don't allow solder to flow down into the holes where the tube pins are inserted. Take a close look at your tube-socket; you can see how easily hot solder might flow into the gripping contact.

2. Place connecting wires low on each lug so that you can make other connections to the same lug later on, if necessary.

Sometimes bare wire is used in wiring a radio receiver because it is easier to work with. However, if the wire is left bare, it may cause a short circuit. In such cases, insulation is added to the wire. A tubular sleeving called *spaghetti* is the insulation used. It comes in many sizes and several thicknesses and is made from a wide variety of insulating materials. It is best, usually, to use the smallest size that will slip over the wire on which you want to use it. Two lengths of spaghetti were sent to you with Kit 1.

When using spaghetti, first cut off the amount that you need and slip it over the wire before any soldering is done. While soldering, keep the spaghetti back from the joint and away from the soldering iron to prevent melting or burning it.

Be sure that the tip of your soldering iron is cleaned and tinned before you start to solder.

Procedure.

Step 1. Turn the tube socket upside down, so that the lugs are facing you and the top of the socket rests on the piece of wood (breadboard). With an awl or scriber, make holes to start the wood screws in the centers of the spaces enclosed by the socket mounting holes. Put the lug underneath the screw hole nearest to lug #7 before you put the screw through the socket mounting hole. Then start and tighten both screws so that

the socket itself cannot slide around. Figure 2-4 shows you how this arrangement should look.

Step 2. Take a piece of single-conductor hook-up wire and push back about 1/4 inch of the insulation. Form a hook as you did in Experiment Lesson 1 and then push the hook through the opening in lug *#1* on the tube socket. Try to keep the wire at the lower end of the opening. (If you received a socket with two holes in each lug, use the lower hole.) Now squeeze the hook to the lug with your long-nose pliers, just as you did in Lesson 1. If the end of the wire sticks out past the edge of the lug, cut it off with a pair of cutting pliers.

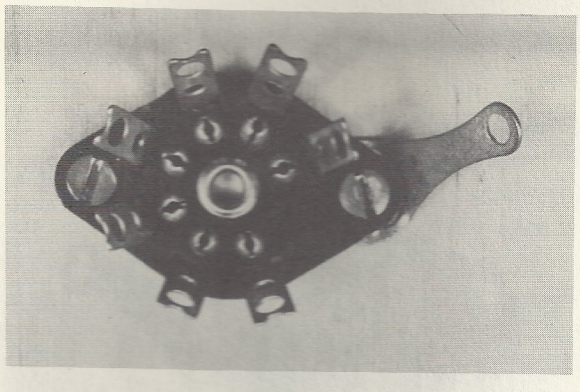


Fig. 2-4

Step 3. If the wire has moved up on the lug, push it down again and tighten it with a pair of long-nose pliers. The finished job should look like Fig. 2-5. Then solder the wire Don't use so much solder that the entire hole is covered; use just enough to make a good soldered joint. Be careful not to let any solder flow down into the tube-pin opening.

Step 4. Cut the wire about an inch from the connection you have just made and pull off the insulation from the piece that is still connected to the socket. Take care not to bend the lug. You now have a piece of bare wire connected to the socket.

Step 5. Slide a long piece of spaghetti over the bare wire. Notice that if you tried to cut the spaghetti now, you wouldn't know where the end of the wire is located. Remove the spaghetti and hold it close to the wire,

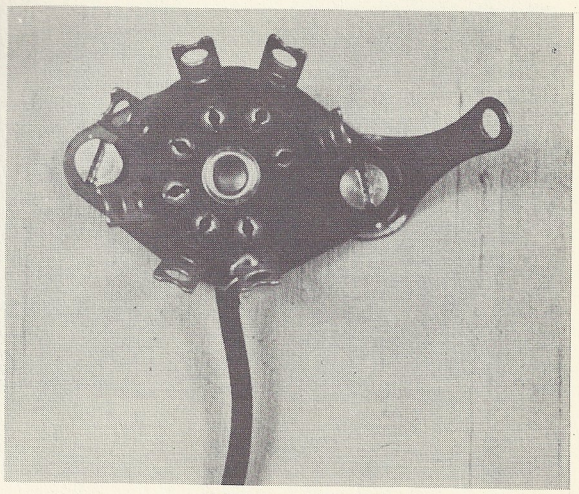


Fig. 2-5

as shown in Fig. 2-6. Cut off a piece of spaghetti that is 1/2 inch shorter than the wire itself and place this short piece of spaghetti on the wire.

Step 6. Make a hook on the bare end of the wire and then push the wire through lug *#3*, just as you did with lug *#1*. Now solder this connection. The socket should look like

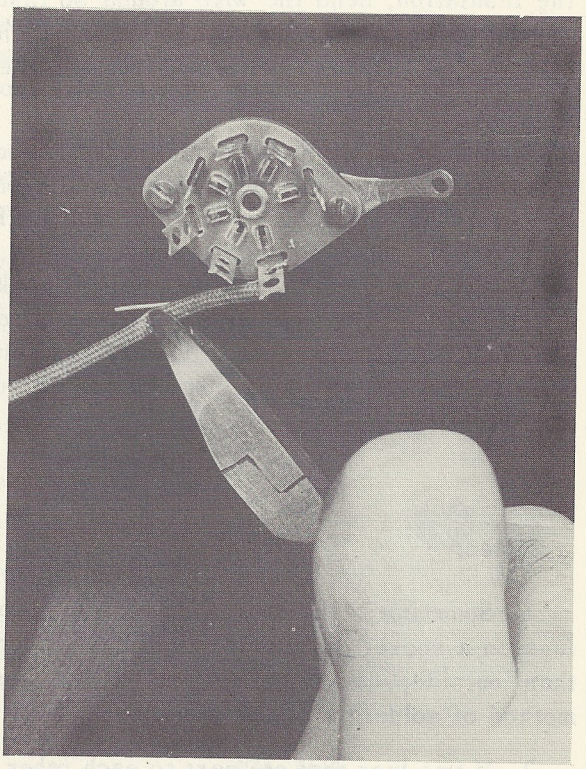


Fig. 2-6

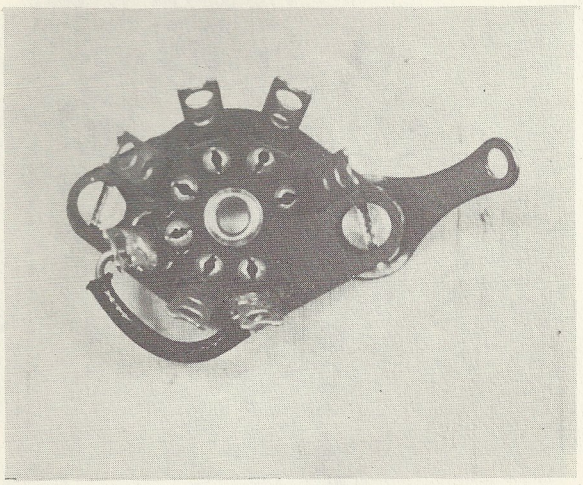


Fig. 2-7

Fig. 2-7. Notice that the wire is a bit slack. It's possible to make a tighter, neater looking job, so let's do it in a slightly different way.

Step 7. Lug *#2* is a blank, unused lug between the two lugs you just soldered. Solder a piece of hook-up wire to the upper hole of this lug in the same way you did to lug *#1*. Before you cut the wire and remove the insulation, bend the wire around so that it passes lug *#3* and lug *#4*. About 1/4 inch past lug *4*, cut the wire and remove the insulation.

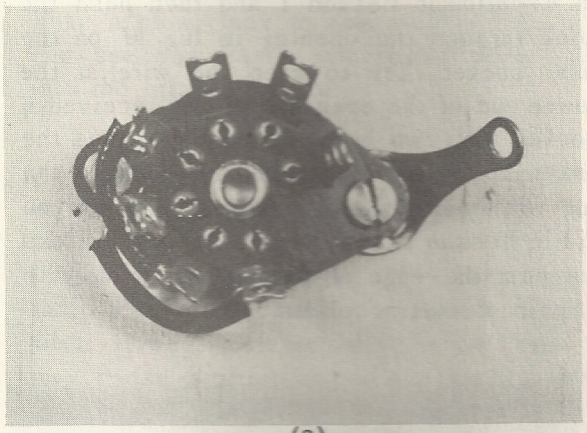
Step 8. Cut off a piece of spaghetti for this piece of wire, the same way you did for the first one. Be sure to put the spaghetti on the wire. Then solder the wire to lug *#4*, as shown in Fig. 2-8*a*, remembering to hook it first and squeeze it with your long-nose pliers. If you have worked carefully, you can see that this second connection looks neater than the first one.

Notes:

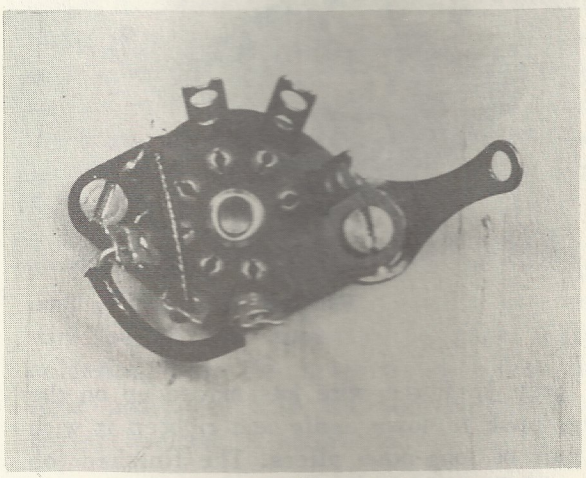
1. Sometimes the wire connecting two lugs on a socket runs inside the lugs, rather than outside, as shown in Fig. 2-8*b*. The method of soldering is the same.

2. If two lugs that are next to each other, such as lugs *#1* and *#2*, are to be connected, no spaghetti is used.

3. When connecting two lugs opposite each other, it's easier to go across the socket than all the way around it, as shown in Fig. 2-8*c*. Spaghetti should be used in such a connection.



(a)



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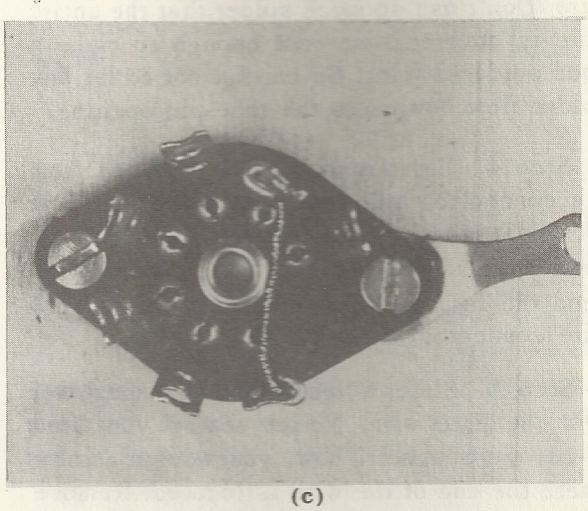


(c)

Fig. 2-8

JOB 2-2

To solder a resistor between the tube socket and a tie terminal.

Equipment Needed.

The equipment used in the last experiment

One tie terminal (terminal strip)

One wood screw

Two resistors remaining from Kit 1

Procedure.

Step 1. There are still three blank lugs on the tube socket you are using. Mount the tie terminal, with the wood screw, about one inch away from the socket, with the broad side of the strip facing lugs #5, #6, and #7. Figure 2-9 shows how this arrangement should look.

Step 2. Insert the wire lead on one end of one resistor in lug #5 on the tube socket. Then, insert the wire on the other end of the resistor through either one of the lugs on the tie terminal. Center the resistor in the space between the tube socket and the tie terminal, as shown in Fig. 2-10.

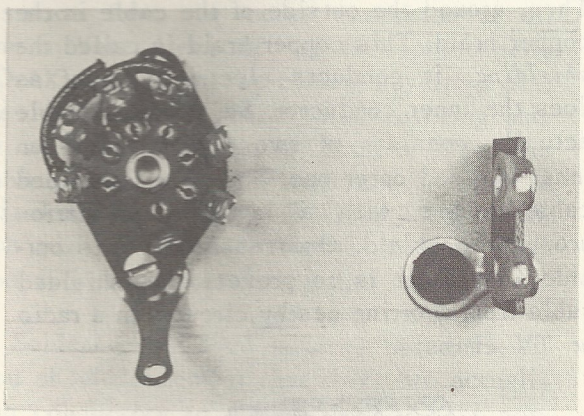


Fig. 2-9

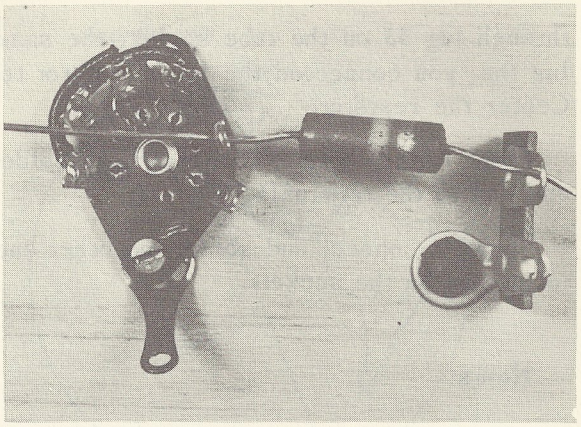


Fig. 2-10

Step 3. Hold the resistor in place with one hand while you hook the end of the wire around the lug on the tie terminal. Press the hooked end together to make a good tight connection. Remember to cut off any excess wire that sticks out past the edge of the lug.

Step 4. Make sure that the wire is down at the bottom of the lug and solder the connection.

Step 5. In the same way, connect and solder the other end of the resistor to the lug on the tube socket. The work should look like what is shown in Fig. 2-11.

Step 6. Push one end of the remaining resistor through the other lug on the tie terminal. Push the other end of the resistor

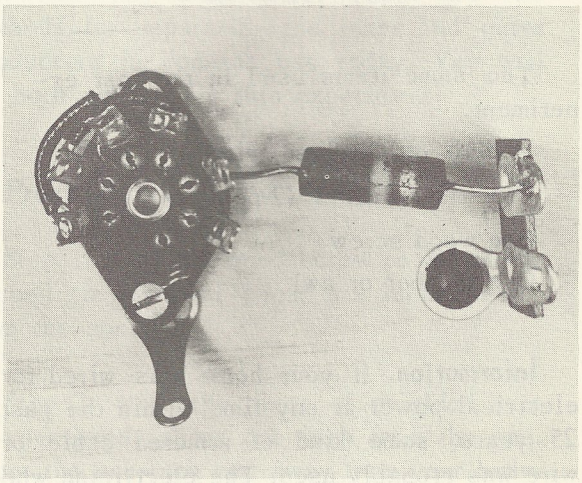


Fig. 2-11

through lug #5 on the tube socket, the same lug that you connected the other resistor to. Center the resistor.

Step 7. As before, connect and solder one end to the terminal.

Step 8. Connect and solder the other end to the lug on the socket.

Notes:

1. Any wire connected to a hole in a lug should be kept at the bottom of the lug to leave room for more wires to be connected later.

2. Always solder a connection as you make it. In that way, you won't leave any connections unsoldered. For example, you might have connected the first resistor to the tube socket and then waited until you connected the second one before soldering. However, if there had been no second connection, you might have forgotten to solder the first.

JOB 2-3

To connect and solder shielded wire.

Equipment Needed.

The same items used in the last experiment.

Length of shielded wire

One tie terminal (2-position)

One wood screw

One scriber or awl

Information. If your home was wired for electrical power at any time within the past 25 years, some kind of armored cable or wire was probably used. The electrician who did the wiring may have used wire that was protected by a curled metal covering. This wire is called *BX cable* and is shown in

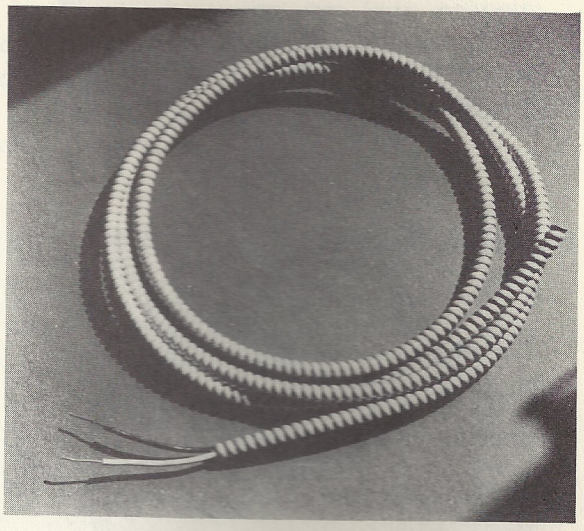


Fig. 2-12

Fig. 2-12. Metal covering is used to protect wire from injury and to protect the house from fire if the wires become shorted.

In radio and TV, a special kind of wire, called *shielded wire* or *shielded cable*, is often used. It is similar in some ways to BX cable. Like BX, the inner wire or wires of shielded cable are covered by a metal tubing, as shown in Fig. 2-13. This metal tubing is much more flexible than the spiral steel tubing wound around. BX cable; it is usually made from tinned strands of copper wire braided together. Look at the piece of shielded cable sent to you in Kit 1. You will see, in the center of the cable, an inner conductor that is very much like stranded hookup wire, protected by a layer of insulation. Then, around the outside of the cable is the copper braid. This copper braid is called the *shielding;* it conducts electricity, just as does the inner conductor. So, shielded cable actually consists of two conductors – an inner one and outer one. Sometimes shielded cable comes with a layer of insulation around the shield. One reason for this outside insulation is to prevent the shielded cable from shorting nearby circuits in a radio or TV chassis.

Fig. 2-13

Shielded cable comes with one, two, three, or more inner conductors. In most cases, the insulation used for shielded cable is rubber, although in some cases it may be plastic.

A very special form of shielded cable, used in radio and TV circuits, is called *coaxial cable*.

You remember from your study of geography that the earth revolves on its *axis*. The axis of the earth is an imaginary line drawn through the center of the earth from the North Pole to the South Pole, as shown in Fig. 2-14*a*. A wire, too, has an axis. A line drawn to show the axis or exact center of a length of conducting wire is shown in Fig. 2-14*b*. A line drawn to show the axis of a length of tubular copper braiding is shown in Fig. 2-14*c*. If we combine the two conductors into a length of coaxial cable, the axis of the inner conductor, as shown in Fig. 2-14*d*, is exactly the same as the axis of the outer braided conductor. So we say that such cable is *coaxial*, because the inner and outer conductors have the same axis.

Examine the length of coaxial cable, sent to you in Kit 1. The insulating material between the inner conductor and the outer metal braid of coaxial cable is made of plastic. In making coaxial cable, great care is taken to keep the thickness of this plastic insulation the same throughout its length. In this way, the inner conductor is the same distance from the outer conductor at all times. Your piece of *co-ax* (pronounced KO-AX) has a woven-cotton covering over the metal shield. This outer covering may be of either rubber or plastic. Put this cable aside now. You will use it later in this lesson to make a shielded lead, which you will use with the signal generator that you will make later during this course.

Soldering shielded wire is not difficult. You should remember that there are actually two conductors to solder. Before it is possible to get at the inner conductor, it must be separated from the outer braid. After this is done, the inner conductor can be treated just like any other wire. There are two methods for separating the inner and outer conductors in common use today. You will try both methods in this experiment.

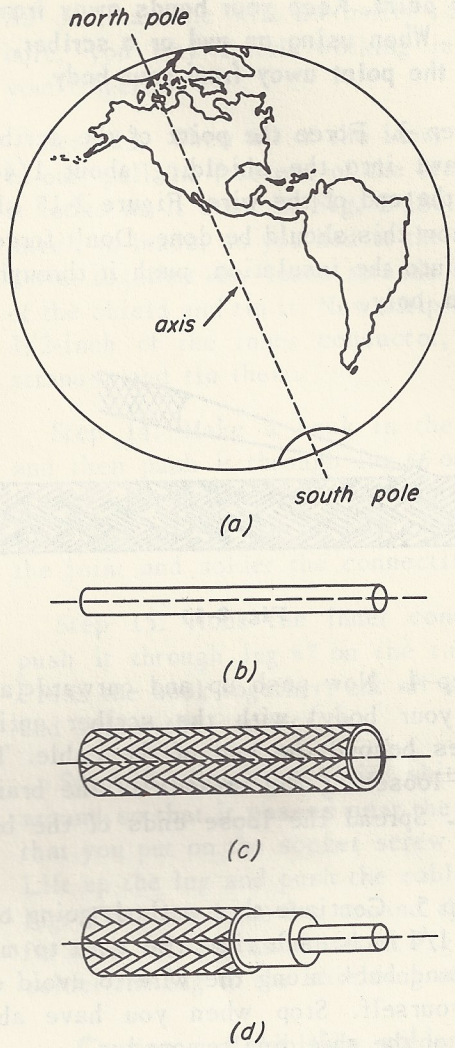


Fig. 2-14

Procedure.

Step 1. Use the wood screw to mount the second tie terminal about six inches away from the socket.

Step 2. Hold the piece of shielded wire in your hand, about one inch from the end. Point the one-inch end away from your body.

Caution: In the next step, you will use either a scriber or an awl. Each has a

sharp point. Keep your hands away from the point. When using an awl or a scriber, work with the point away from your body.

Step 3. Force the point of the scriber or the awl into the shielding about 1/4-inch from the end of the wire. Figure 2-15 shows you how this should be done. Don't force the pick into the insulation; push it through the shield only.

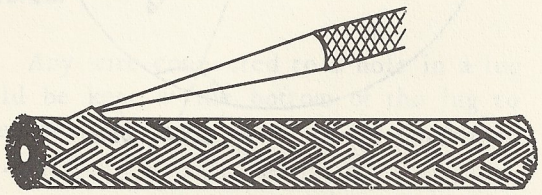


Fig. 2-15

Step 4. Now push up and outward (away from your body) with the scriber until it reaches beyond the end of the cable. This starts loosening the strands of the braided shield. Spread the loose ends of the braid apart.

Step 5. Continue this method, going back about 1/4 inch each time. Be sure to move your hand back along the wire to avoid cutting yourself. Stop when you have about 1 inch of the shielding removed.

Step 6. Hold the 1-inch piece of the inner conductor in one hand and, with the other hand, twist the shielding so that it forms a stranded wire, as shown in Fig. 2-16*a*.

Step 7. Tin the inch of shielding that you just twisted. If you are careful, you can tin it all the way back to where it joins the inner conductor. However, be sure not to burn the insulation.

Step 8. Strip about 1/2 inch of the insulation from the inner conductor in the same way that you would strip any other wire. If the inner conductor is a stranded wire, twist it and tin it. The cable end should now look as shown in Fig. 2-16*b*.

Step 9. Hook the tinned shield and push it through one of the lugs on the tie terminal

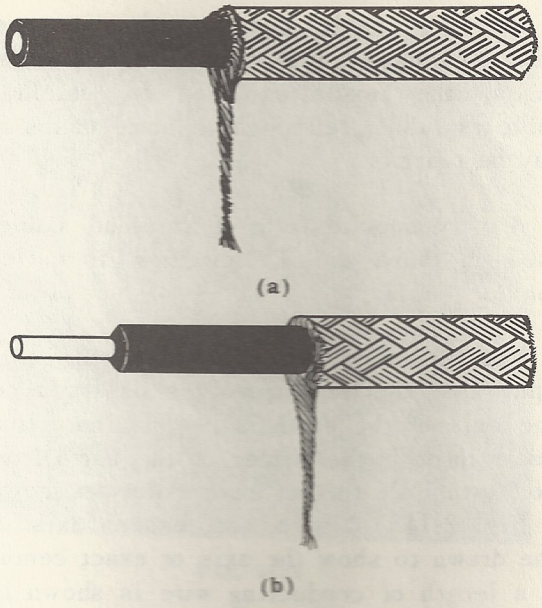


Fig. 2-16

that you mounted in Step 1. Press the hook together tightly with your long-nose pliers. Cut off any excess and then solder the connection.

Step 10. Connect the inner conductor to the other lug on the terminal strip and solder it. Figure 2-17 shows the two connections you have made.

Step 11. Hold the other end of the shielded cable about two inches from the end. Push the shielding back just as you would insulation on pushback wire. Then pull it back almost to its original position. Bend the cable. This loosens the braid. About one inch from this end, use the awl or scriber to start a hole in the braided shielding. Do this by spreading the braided

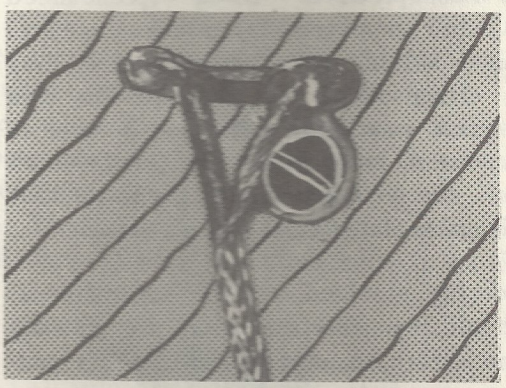
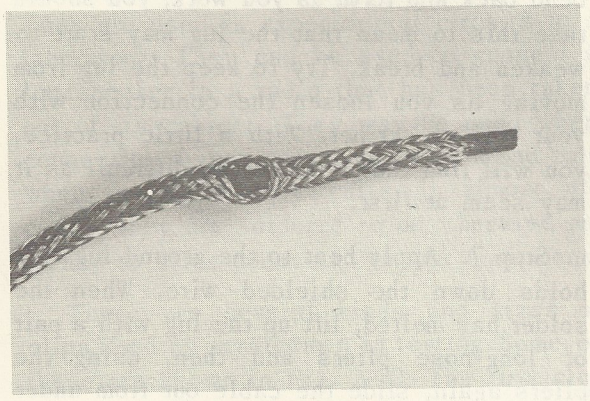
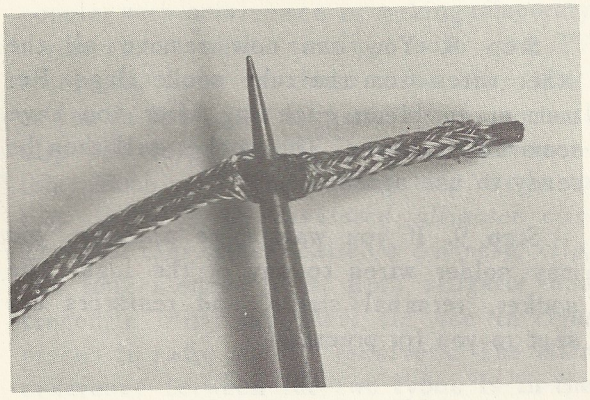


Fig. 2-17

strands apart. Work the point back and forth carefully until the hole is large enough to pull the inner conductor through. See Fig. 2-18*a* and *b*.



(a)



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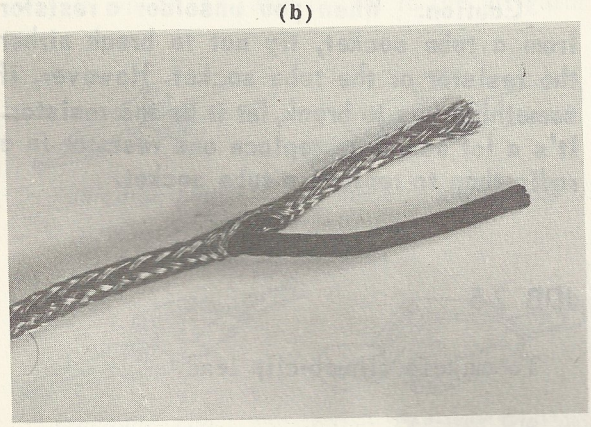


(c)

Fig. 2-18

Step 12. Now push the point of your awl *under* the inner conductor. Be careful not to damage the insulation as you pull the inner conductor out through the hole you have made in the braid, as shown in Fig. 2-18*b*. As soon as the wire is partly through the hole, you may finish working it out with your fingers.

Step 13. When all of the inner conductor is out, pull the free end of the braid so that it looks as it does in Fig. 2-18*c*. You now have two leads, as you had at the other end. Twist together any loose strands at the end of the shield and tin it. Now strip back about 1/2-inch of the inner conductor, twist the strands, and tin them.

Step 14. Make a hook in the shielding and then push it through lug #6 on the tube socket. Press the hook together with your long-nose pliers. Cut off any excess wire at the joint and solder the connection.

Step 15. Hook the inner conductor and push it through lug #7 on the tube socket. Press the hook together, cut off any excess, and solder the connection.

Step 16. Bend the entire shielded cable around so that it passes near the ground lug that you put on the socket screw in Job 2-1. Lift up the lug and push the cable under the lug. Then bend the lug around the cable as far as it will go, as shown in Fig. 2-19. Now solder the lug to the shielding of the cable.

Caution: Make this soldered connection as quickly as possible to avoid melting

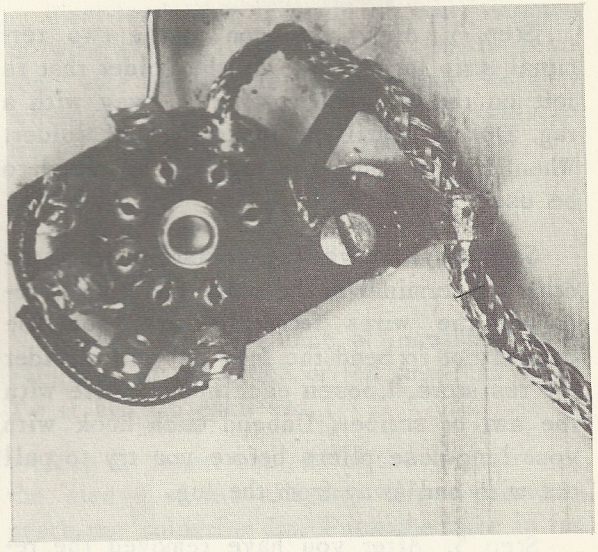


Fig. 2-19

or burning the insulation. If you do not make a good joint the first time, allow the lug and shielding to cool off before heating the joint again.

JOB 2-4

To unsolder all connections made so far in this lesson.

Equipment Needed.

Same as in the last experiment.

Caution: Hot solder may splatter as you pull out a wire from a connection. Keep your eyes as far away as possible and tug gently on the wire.

Procedure.

Step 1. Apply your soldering iron to the lug on the tie terminal to which you soldered the shielding. When the solder starts to melt, loosen the hooked end, using the scriber or awl, as you did in Lesson 1. Loosen the joint. Then, use the long-nose pliers to grasp the end of the wire, and pull the shield out.

Step 2. After you have removed the shield from the lug, unsolder the inner conductor from the other lug in the same way.

Step 3. Apply the iron to the two terminal strip lugs again. As the solder that is left on the lug melts, wipe it away with a rag. Do this until the lug is free of solder. When this is done, the lug will be ready to be used again.

Step 4. Remove the resistors from the other tie terminal in the same way as you removed the wires from the first one. Be careful not to bend the lugs as you unsolder the resistors. Loosen each hooked wire with the awl or scriber. Unbend each hook with your long-nose pliers before you try to pull the wire end away from the lug.

Step 5. After you have removed the resistors, clean the tie terminal as you did the other one.

Step 6. Now remove the resistors from the tube-socket lug. This will be even a little more difficult than removing the resistors from the terminal strip lugs. If you see the lug on the tube socket starting to bend back and forth as you work, you should take this to mean that the lug may start to weaken and break. Try to keep the lug from moving as you loosen the connection with your awl or scriber. With a little practice, you will find that it is not as difficult as it may seem at first.

Step 7. Apply heat to the ground lug that holds down the shielded wire. When the solder has melted, lift up the lug with a pair of long-nose pliers and then, using the pliers again, slide the cable out from under the lug.

Step 8. You can now remove all the other wires from the tube socket lugs. Remember to clean each lug after you have removed the wires. The socket will then be ready to use again.

Step 9. If you want more practice, you may solder wires to any of the lugs. The socket, terminal strips, and resistors are sent to you for practice.

Caution: When you unsolder a resistor from a tube socket, try not to break either the resistor or the tube socket. However, if something has to break, let it be the resistor. It's a lot easier to replace one resistor in a radio than to replace a tube socket.

JOB 2-5

To make a clip-to-clip lead.

Equipment Needed.

Breadboard

Wood screw

Piece of test-lead wire about 1 foot long (cut from the 4-foot length of red testing wire sent you)

Two alligator clips

Nail set or screwdriver

Information. Test clips are used on wire leads that connect test equipment to a radio. They are used in experimental circuits in a laboratory. They can be used to connect a loudspeaker to a radio that has been taken out of its cabinet. They may be used when connecting a good part in place of a bad part when testing radio circuits. In almost all cases, they are soldered to or otherwise attached to wires connected to test equipment.

There are several kinds and sizes of clips used by servicemen in testing. Some of these are shown in Fig. 2-20. The first clip shown, called an *alligator clip,* is very popular with servicemen in making temporary connections while testing radio and TV receivers. Some of these clips were sent to you in Kit 1. An alligator clip is a small clip with long, slender jaws and a convenient thumb grip. The second clip shown in Fig. 2-20 is an *insulated alligator clip.* The next clip shown, called a *crocodile clip,* has long slender jaws. Both alligator and crocodile clips are ideal for use in tight places in radio and TV receivers. The main difference between the two types is in the way in which the jaws hinge. In the alligator clip, only the upper jaw, attached to the thumb grip, moves; in the crocodile clip, both jaws move. The next clip shown is the *Pee-Wee Clip,* which is very handy in making temporary connections to screw terminals and to binding posts. Larger sizes of the same type of clip are used in making temporary connections to storage batteries. The next clip shown is the *Twin Clip,* which is handy in making temporary connections between two or more wires or wire leads. The last clip shown is the *Wee-Pee-Wee Clip.* This clip is very small and slender and, because it is made of phosphor bronze and not of iron or steel, can be used in testing radio coils without becoming magnetized.

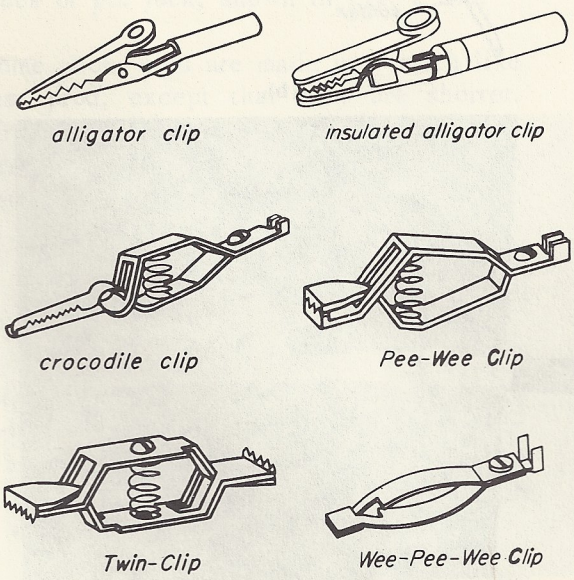


Fig. 2-20

If necessary, almost any kind of wire found around a radio shop may be used with test clips for making temporary test connections. However, for making handy clip leads and other test leads, a special type of wire, called *test-lead wire,* is used by radio and TV technicians. Some test lead wire was sent to you in Kit 1.

Look at a piece of the test lead wire that was sent to you. You will see that the insulation around it is heavier than the insulation around the other wire in your kit. The wire itself is quite thick. The heavy insulation helps to protect the user from shock.

Test-lead wire is made of many strands of wire twisted together. This makes test-lead wire much more flexible than ordinary wires, so that it always tends to return to its original shape, even if twisted.

Procedure

Step 1. Strip 1/2 inch of insulation from each end of the piece of red test-lead wire. Twist and tin each end.

Step 2. Insert one end of the wire through the sleeve of the alligator clip and underneath the soldering lip. Push the wire in far enough so that the insulation on the wire goes about 1/4 inch into the sleeve.

Step 3. Tighten the connection by pressing the lip back toward the rear of the clip with a nail set or screwdriver blade, as shown in Fig. 2-21*a*.

Step 4. Solder the wire and lip, as shown in Fig. 2-21*b*. Be sure to clean off any excess solder with a rag. Make the soldered joint as smooth as you can. Figure 2-21*c* shows how it should look.

Step 5. Attach the other alligator clip to the other end of the wire in the same manner.

Notes:

1. Do not take the clip-to-clip lead apart. You will use it in later experiments.

2. Save the other alligator clips for use in later lessons.

JOB 2-6

To make a pair of test leads.

Equipment Needed.

Two test prods

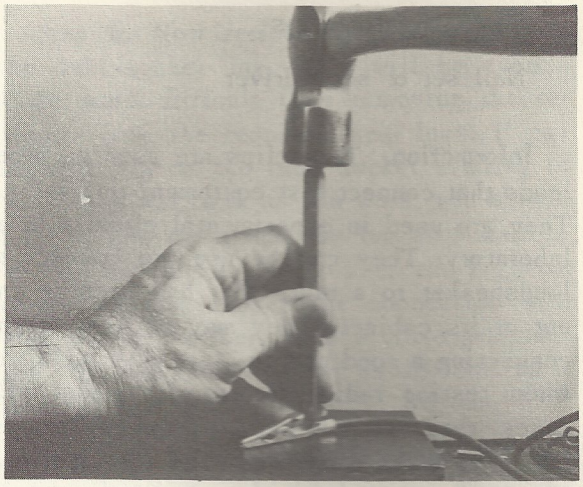
Two phone tips

Two pieces of test-lead wire (3-foot lengths)

Breadboard

Nail of same thickness as thin end of phone tip

Information. A *test prod* or *test probe* is often used in tight places. A test prod is shown in Fig. 2-22. A simple test prod has tips instead of clips, so you must hold a test prod in place with your hand. Look at one of the test prods sent to you in Kit 1. The body is insulated and long so that it may be held without danger of electric shock. Notice also that it is easy to hold with the hand. Test prods are made in several colors, but black and red are the most popular.



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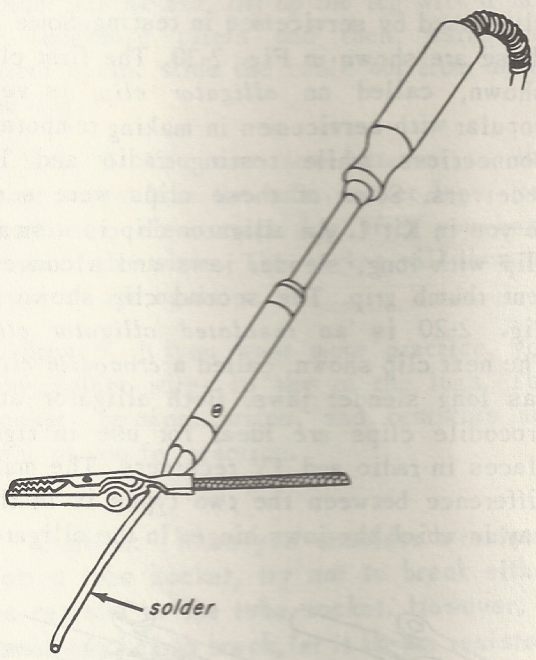

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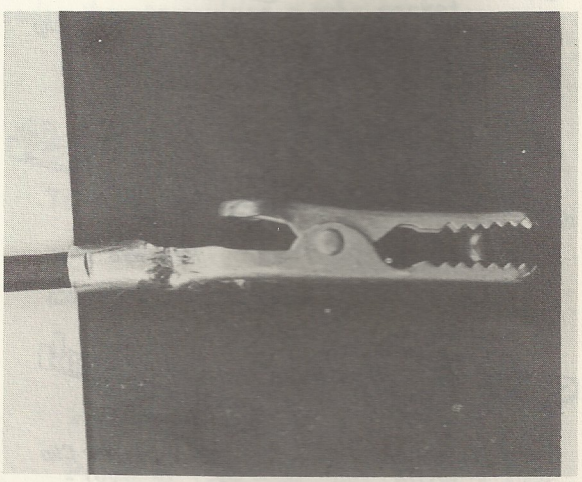

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Fig. 2-21

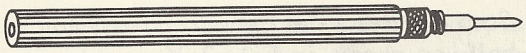


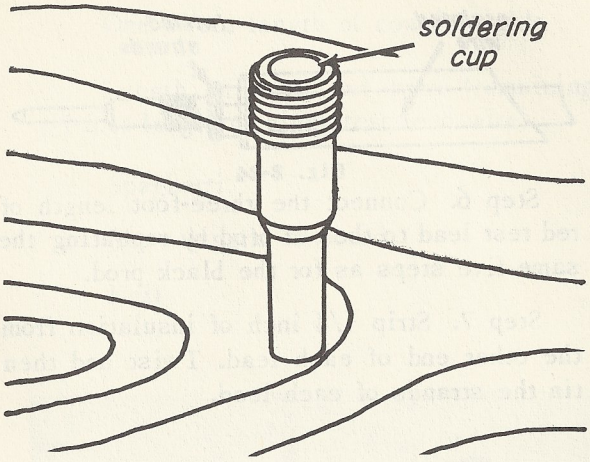
Fig. 2-22

Different colors allow you to tell one prod from the other when testing a radio or TV receiver. Test prods are often more convenient than alligator clips, as you will learn later on in the course.

There are two basic ways to connect a wire to a test prod. The bodies of some prods can be unscrewed, and the wire can be soldered to a small cup-like piece at the shank of the prod, as shown in Fig. 2-23*a*. Another type of prod, such as the one you received in your kit, has a small knurled nut screwed on the shank. This nut can be removed, exposing a small hole. The wire is pushed through the body of the prod until it comes out of the hole. It is then bent around the shank and the nut is replaced. This is an easy method of connecting a wire to the prod.

Phone tips are often used in making temporary connections. A phone tip, like those you received in the kit, is just a piece of conducting metal with an opening at the top into which a wire can be soldered. It makes a good connector because it is very rigid. Phone tips fit into an opening known as a *tip jack* or *pin jack*, shown in Fig. 2-23*b*.

Some phone tips are made very much like a test prod, except that they are shorter. Their only advantage is that they have insulated bodies. Electrically, they make no better connection than the plain type, and they are much easier to damage.



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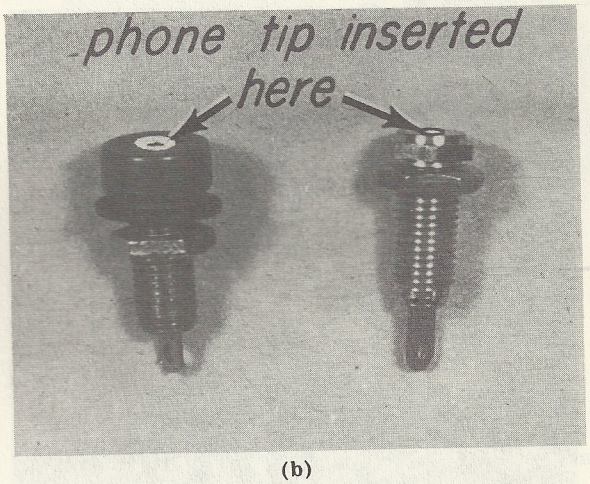


(b)

Fig. 2-23

Procedure.

Step 1. Cut one 3-foot length of black test-lead wire from the 4-foot length sent you and strip one inch of the insulation from one end. Twist the strands together and tin the wire.

Step 2. Remove the knurled nut on the shank of the black test prod by twisting it counterclockwise. Notice that there is a small hole in the shank, up near the start of the body.

Step 3. Put a slight curve on the tinned end of the wire and push it into the body of the test prod. The object here is to make the wire come out of the small hole. If you are lucky, it will come out immediately. If the wire doesn't come right through, hold the wire and turn the test prod slowly until you feel the wire catch in the hole. Then push it all the way through.

Step 4. Pull the end out as far as it will go and then bend the wire around the shank, just under the lip that appears above the hole, as shown in Fig. 2-24.

Step 5. The nut is made to fit over the wire you just bent around the shank. Replace the nut on the shank and be sure to tighten it exactly as it was before you removed it.

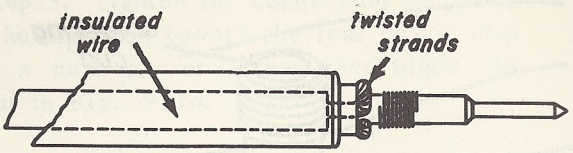


Fig. 2-24

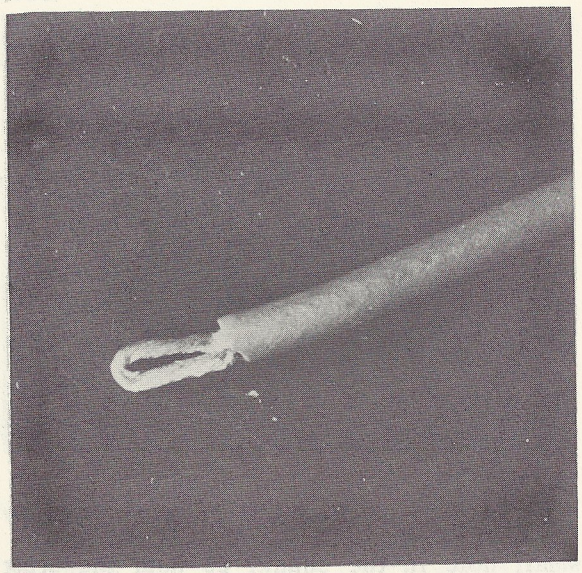
Step 6. Connect the three-foot length of red test lead to the red prod by repeating the same five steps as for the black prod.

Step 7. Strip 3/4 inch of insulation from the other end of each lead. Twist and then tin the strands of each lead.

Step 8. Bend the tinned end of each lead in half, as shown in Fig. 2-25*a*.

Step 9. Drive a nail of the same thickness as the thin end of the phone tip part way (about 1/2 inch) into the breadboard. Then remove the nail from the board. The hole in the breadboard will provide a support for the phone tip while you solder it.

Step 10. Place one of the phone tips in this hole. Be sure that it is held rigidly and the open end faces you, as shown in Fig. 2-25*b*.



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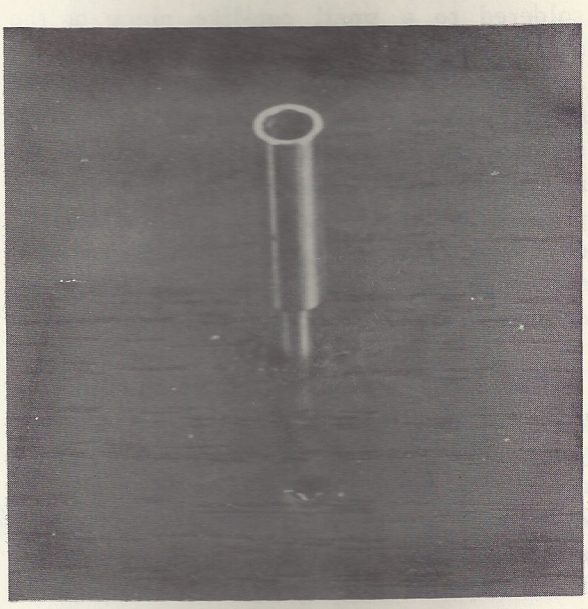

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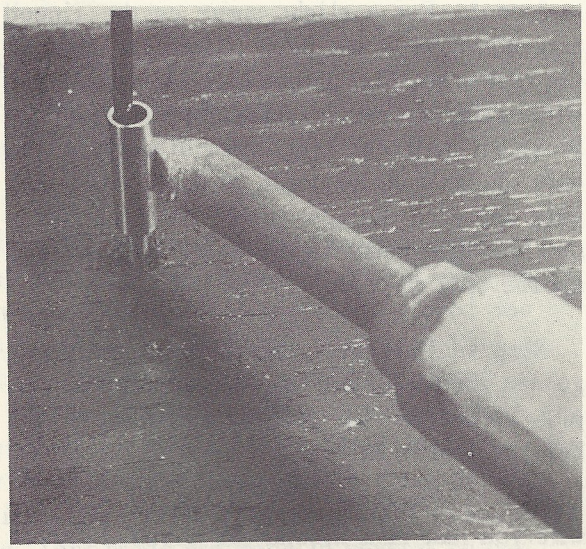

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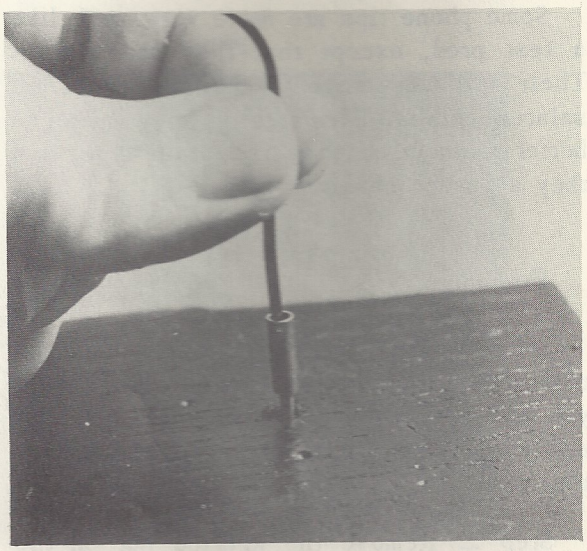


(d)

Fig. 2-25

Caution: In the following steps, some hot solder may splatter. Keep your eyes a good distance from the phone tip while you solder it.

Step 11. Cut a piece of solder just long enough to fit inside the phone tip. Place it in the open end of the tip.

Step 12. Hold the iron against the side of the tip, as in Fig. 2-25*c*, until the solder inside melts. Then insert the folded end of one test lead slowly into the opening of the tip. Allow it to go in as far as possible and then, as you remove the iron, hold the wire in place, as shown in Fig. 2-25*d*. Allow the phone tip to cool off for a minute; then remove the tip from the breadboard and test it by tugging gently at the wire while holding the phone tip with a pair of pliers. If the wire comes loose, you will have to repeat the soldering operation.

Step 13. In the same way, solder a phone tip to the tinned end of the other test lead.

Notes:

1. In soldering a phone tip, hold it tightly so that it cannot move and possibly cause a cold-soldered joint.

2. Clamping a phone tip in a vise is not recommended, because the metal jaws of the vise conduct the heat away from the phone tip.

3. The test leads you have just assembled are for use with your multimeter. Do not take them apart. When they are not in use, you might fold them as shown in Fig. 2-26.

JOB 2-7

To remove two-inches of insulation from each end of your three-foot lengths of coaxial cable.

Equipment Needed.

Two alligator clips

Two phone tips

One 3-foot length of coaxial cable

Length of test-lead wire (remaining 1-foot length of black test lead wire)

Spaghetti

Short length of board

Nail

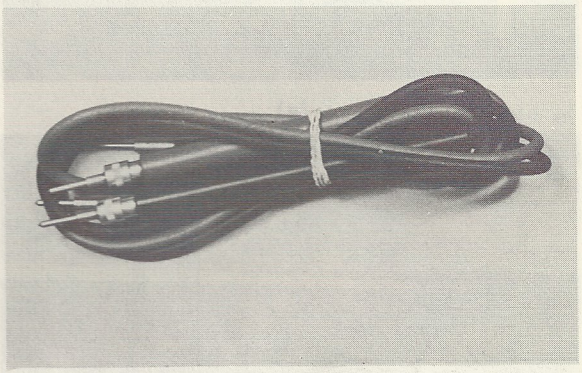


Fig. 2-26

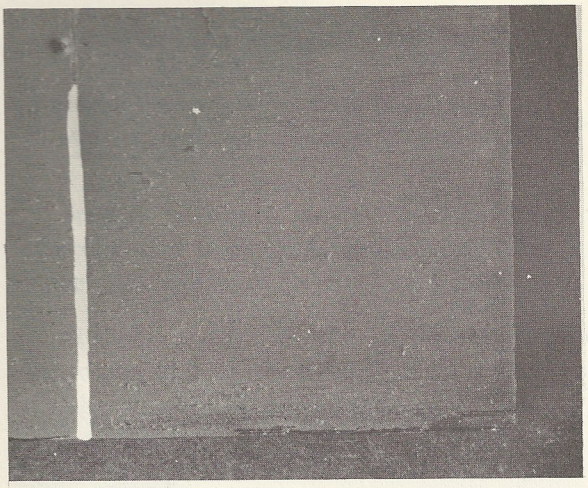
Information.

Until now, we have suggested that you always remove insulation by a method that looks very much like whittling. It is the best method to use in most cases. However, the outer covering of your *co-ax* is made from a very tough plastic or rubber. The neat removal of such material calls for a different method, which you will try now.

Procedure.

Step 1. Mark off a line two inches from the end of the breadboard, as shown in Fig. 2-27*a*.

Step 2. Place the end of the cable even with the end of the board. Then hold your knife edge on the outer insulation of the cable at the two-inch line as you hold the cable flat against the surface of the wood with your other hand, as shown in Fig. 2-27*b*. Your object, at this point, is to cut part way through the outer insulation. Keep a steady, even, and light pressure with your knife against the insulation as you roll the cable



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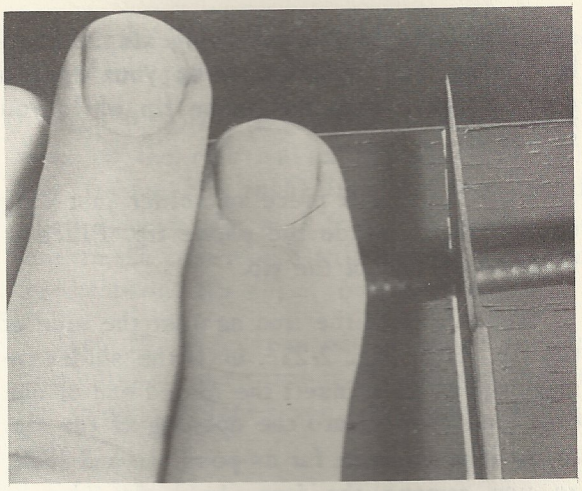

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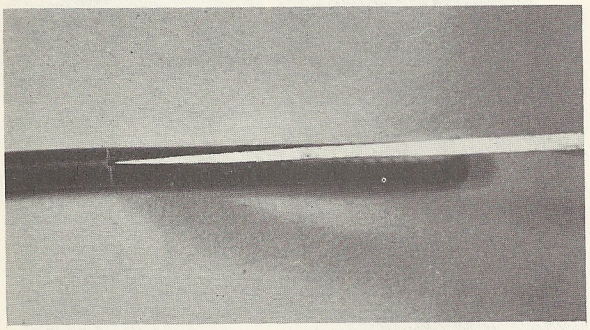

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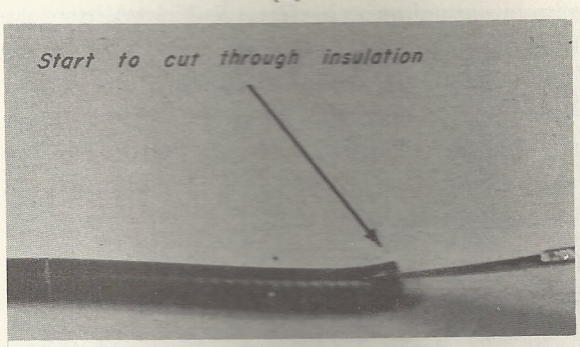

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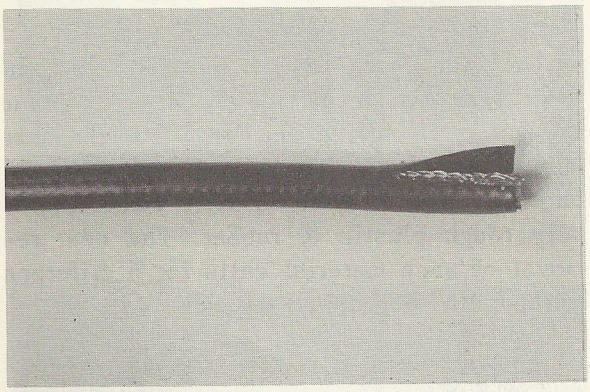

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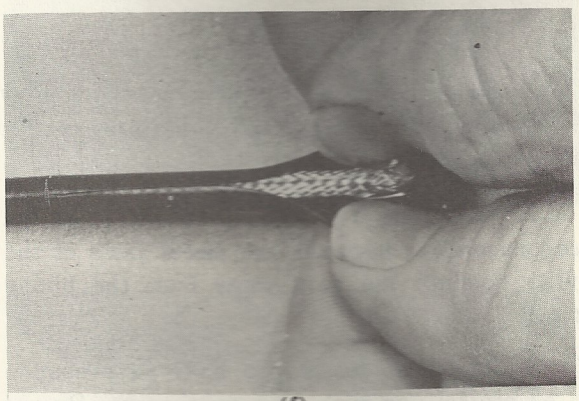

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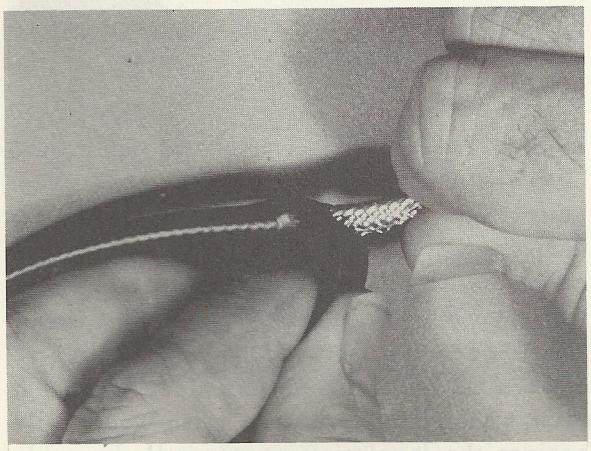

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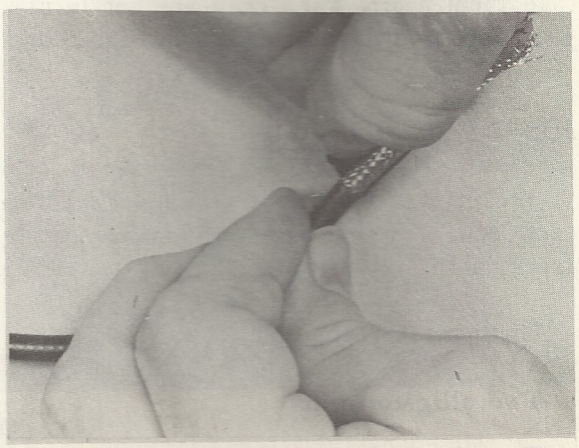


(h)

Fig. 2-27

back and forth with your other hand. Be careful not to cut too deeply into the insulation.

Step 3. Next, hold the cable as shown in in Fig. 2-27*c*, and, using the same pressure as before, draw your knife from the circular cut you just made back to the end of the cable. It is better to take several light strokes rather than to cut through the insulation and possibly tear the shielding.

Step 4. Starting at the very end of this cut and working back about 1/4-inch from the cable end, cut the insulation all the way through, as shown in Fig. 2-27*d*. Be careful not to cut the shielding.

Step 5. As soon as the insulation has been cut through, force your thumbnail under the insulation and, with your thumb and forefinger, pull away the insulation from the cable, forming a small triangular flap, as shown in Fig. 2-27*e*. Form a similar flap at the other side of the cut, so that, when you are through, you can use the thumb and forefinger of each hand to tear the insulation along the line of the long cut, as shown in Fig. 2-27*f*.

Step 6. When you have loosened the insulation a distance of about 1/2 inch, hold the loosened flap in one hand and the inner shielded cable with the other hand and pull back, as shown in Fig. 2-27*g*, toward the two-inch line.

Step 7. At this point, the insulation may tear away completely up to the two-inch line. If not, tear the insulation away along the two-inch line, as shown in Fig. 2-27*h*.

This job takes longer to tell about than to do, although you may find it more difficult to do the first time you try it than you will later on.

Step 8. In the same manner, remove two inches of insulation from the other end of the cable.

JOB 2-8

To make a shielded test cable.

Procedure.

Step 1. Pull the inner conductor through the shielding as you did when you used the second method of Job 2-3. Do this for both ends of the cable. You will find that this inner conductor is a little stiff to work with, because it is solid wire.

Step 2. Draw the braided shield out carefully to its normal length by gently pulling on it. Do this at both ends of the cable. Twist the end of each braid as you would twist stranded wire.

Step 3. Tin each of these loose ends of braid back for about one inch from the end. The plastic used in the inner insulation melts at a low temperature, so be very careful not to get the iron too close to it. At this point, each end should look like the picture in Fig. 2-28.

Step 4. Remove about 1/4 inch of the plastic insulation from one end of the inner conductor of the cable, using the usual whittling method. You will find that this plastic insulation is more difficult to remove, so work carefully and don't be impatient. In this way, you will avoid cutting yourself or nicking the inner wire.

Step 5. Carefully tin the exposed copper wire without melting the plastic insulation.

Step 6. Insert the tinned wire through the sleeve and under the soldering lip of one of

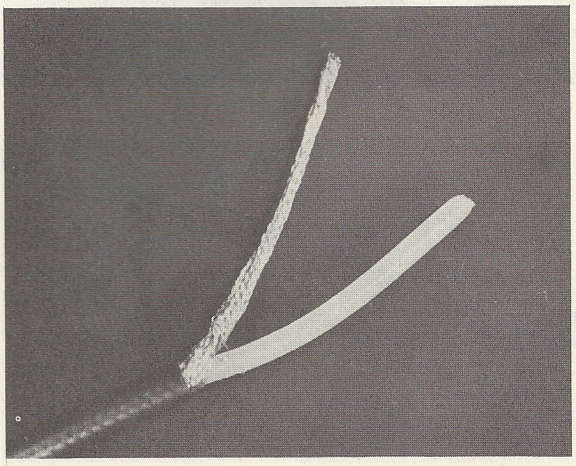


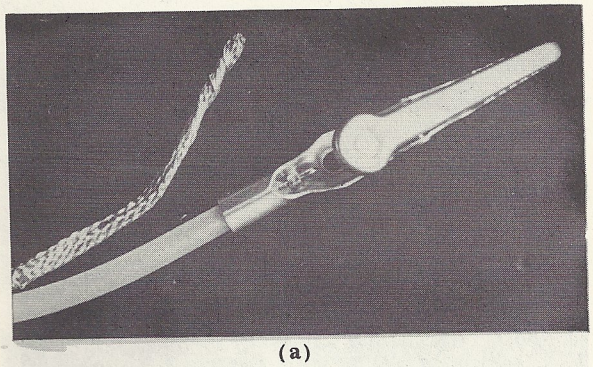
Fig. 2-28

the alligator clips. The wire will be inserted far enough when about 1/4 inch of plastic insulation is inside the sleeve of the clip. With the wire in this position, hold the clip flat on the board, as illustrated in Fig. 2-21*a*. With a nail set or a screwdriver blade, force the soldering lip down toward the wire and toward the back of the clip. If you do this properly, there should be a good mechanical connection between the wire and the clip.

Step 7. Clip the alligator clip to the nail on the breadboard, as you did when you made the clip-to-clip lead. Using only the point of the iron on the underside of the clip, quickly solder the connection.

Step 8. Cut your 1-foot length of black test lead wire in half. Put one piece away; you'll need it in a later lesson. Remove 1-inch of insulation from one end of the other 6-inch length. Solder this end to the end of the loose braid next to the clip, as shown in Fig. 2-29*b*.

Step 9. Cut a 2-inch length of the wide spaghetti and slip it over the test-lead wire, up over the joint you have just soldered, until it reaches the plastic insulation.



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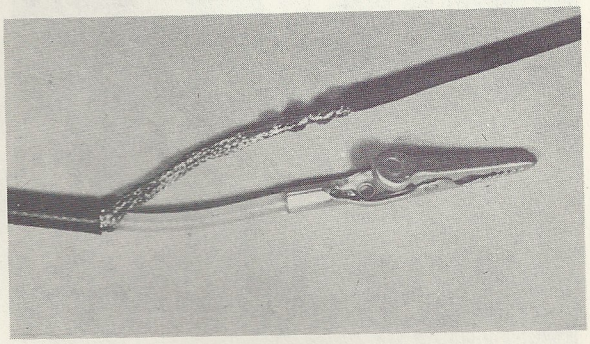


(b)

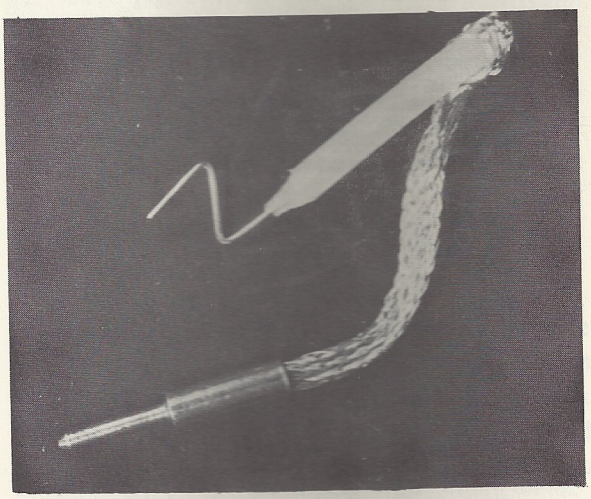
Fig. 2-29

Step 10. Remove 1/4 inch of insulation from the other end of the 6-inch length of test lead. Twist the strands together and tin them.

Step 11. Slip this tinned wire through the sleeve and under the soldering lip of the remaining alligator clip until the insulation is just before the end of the sleeve, so that you can see the wire on both sides of the soldering lip. With the wire in this position, make a good mechanical connection as before and then solder it.

Step 12. Solder a phone tip to the end of tinned braid at the other end of the cable.

Step 13. Remove 1 inch of plastic insulation from the inner conductor at the same end of the cable. Be careful not to nick the wire.



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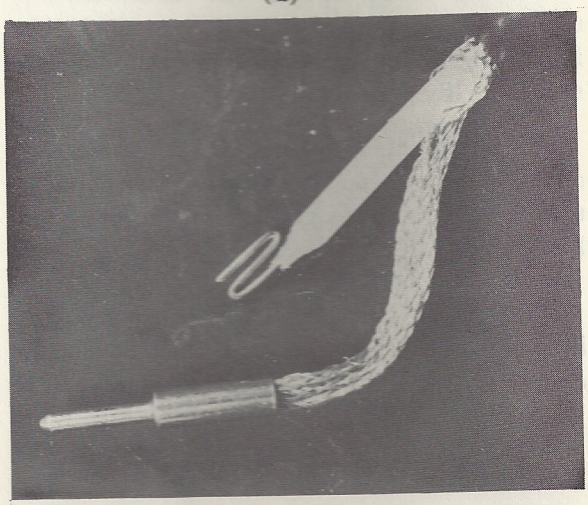

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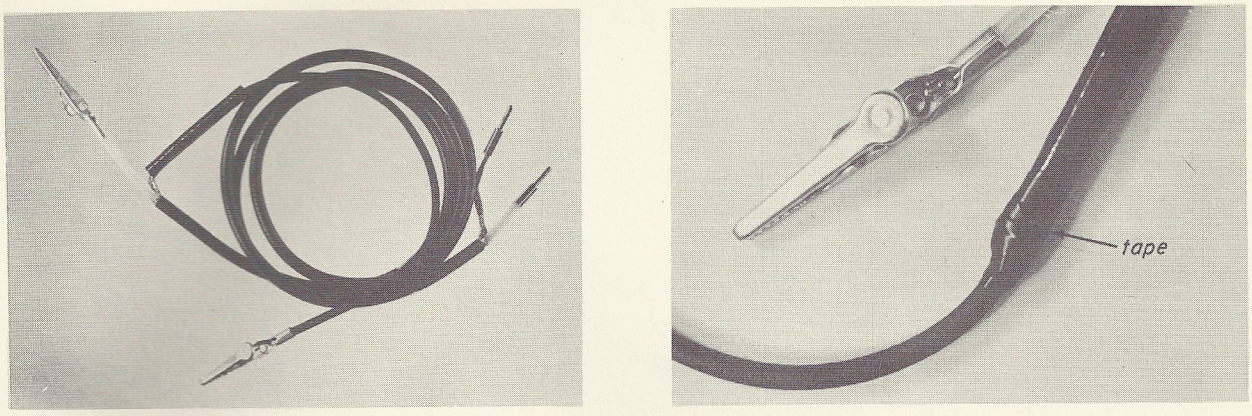
Fig. 2-30



(a) (b)

Fig. 2-31

Step 14. Tin this exposed wire and bend it in the shape shown in Fig. 2-30*a*. Make the first bend at the end of the wire, and the second bend (in the opposite direction) about 2/3" from the end of the wire. Press the Z-bend together until it looks like the bend in Fig. 2-30*b*. You can tell that it is close enough together when the Z-bend just fits into the open end of the phone tips.

Step 15. Solder the tinned end of the wire that you bent in Step 14 into the phone tip. Be careful when you are soldering that you do not apply too much heat or you will melt the plastic insulation.

Notes:

1. You have just made a shielded cable that you will use later with your signal generator and in other test work. Do not take it apart. Coil it, as shown in Fig. 2-31*a*, and keep it with your test leads.

2. If the spaghetti sleeving tends to slip away from the joint, you can keep it in place by wrapping about 1 inch of black plastic electrician's tape (some was sent to you in in Kit 1) around it, as shown in Fig. 2-31*b*.

3. Put away the black plastic electrician's tape, because you will need it again in Experiment Lesson 5.